NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Cost Benefit Analysis of Pier Refueling versus Barge Refueling at the Fleet Industrial Supply Center Fuel Facility Pearl Harbor, Hawaii

By: **Roy Drake**

June 2003

Advisors: **Raymond Franck,**
Donald Eaton

Approved for public release; distribution is unlimited.

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT D*ATE** June 2003	**3. REPORT TYPE AND DATES COVERED** MBA Professional Report	
4. TITLE AND SUBTITLE: Cost Benefit Analysis of Pier Refueling versus Barge Refueling at the Fleet Industrial Supply Center Pearl Harbor, Hawaii			**5. FUNDING NUMBERS**
6. AUTHOR(S) Roy Drake			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT ***(maximum 200 words)***

The purpose of this MBA project was to complete a cost-benefit analysis of refueling via pipeline versus refueling via barge at Pearl Harbor, Hawaii. The alternatives are (1) refueling via a combination of pipeline and barge (status quo), (2) refueling via a single pipeline, and (3) refueling via barge only. The objective was to compare the three alternatives, choosing that alternative that provides the greater net benefit and most efficient use of resources. The analysis involved data collection of labor costs, pipeline operations (flow rates data, costs of repairs, and operational costs), barge operational costs, and environmental protection costs. This Cost Benefit Analysis (CBA) will be valuable to personnel with approval authority who make decisions on the merits of future pipeline projects. This CBA can be used to evaluate other Navy bases' refueling operations worldwide.

14. SUBJECT TERMS PETROLEUM MANAGEMENT			**15. NUMBER OF PAGES** 59
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited.

COST BENEFIT ANALYSIS OF PIER REFUELING VERSUS BARGE REFUELING AT THE FLEET INDUSTRIAL SUPPLY CENTER FUEL FACILITY PEARL HARBOR, HAWAII

Roy Drake, Lieutenant Commander, United States Navy

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
June 2003

Author: _____________________________________
Roy Drake

Approved by: _____________________________________
Raymond Franck, Lead Advisor

____
Donald Eaton, Support Advisor

____
Douglas A. Brook, Dean
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

COST BENEFIT ANALYSIS OF PIER REFUELING VERSUS BARGE REFUELING AT THE FLEET INDUSTRIAL SUPPLY CENTER FUEL FACILITY PEARL HARBOR, HAWAII

ABSTRACT

The purpose of this MBA project was to complete a cost-benefit analysis of refueling via pipeline versus refueling via barge at Pearl Harbor, Hawaii. The alternatives are (1) refueling via a combination of pipeline and barge (status quo), (2) refueling via a single pipeline, and (3) refueling via barge only. The objective was to compare the three alternatives, choosing that alternative that provides the greater net benefit and most efficient use of resources. The analysis involved data collection of labor costs, pipeline operations (flow rates data, costs of repairs, and operational costs), barge operational costs, and environmental protection costs. This Cost Benefit Analysis (CBA) will be valuable to personnel with approval authority who make decisions on the merits of future pipeline projects. This CBA can be used to evaluate other Navy bases' refueling operations worldwide.

.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ABBREVIATIONS, ACRONYMS, SYMBOLS

CBA	Cost Benefit Analysis
CG	Guided Missile Cruiser
CM	Corrective Maintenance
COMNAVBASEPEARLINST	Commander of Naval Base Pearl Harbor Instruction
CV	Conventional Aircraft Carrier
DDG	Guided Missile Destroyer
DFM	Diesel Fuel Marine
E 7/6/5/4/3/2	Enlisted rankings 2 through 7 pay grades
FF	Frigate
FFG	Guided Missile Frigate
FISC PH	Fleet Industrial Supply Center Pearl Harbor
Gallon/N. mile	Gallons Per Nautical Mile
GS	General Salary
HIES	Hawaii International Environmental Services, Inc.
LOGREQ	Logistics Request
MSC	Military Sealift Command
NATO	North Atlantic Treaty Organization
NPV	Net Present Value
OMB	Office of Management and Budget
OSOT	Oil Spill Response Team
PM	Preventive Maintenance
PV	Present Value
RIMPAC	Rim of the Pacific
SWOB	Ship Waste Offloading Barge
T-AO	MSC Fleet Auxiliary Oiler
USNS	United States Naval Ship
USS	United States Ship
WG	Wage Grade
YON	Fuel Oil Barge

THIS PAGE INTENTIONALLY LEFT BLANK

I. BACKGROUND

In 1997, a cost assessment was performed on the Fleet Industrial Supply Center Fuel Department at Pearl Harbor (FISC PH) by a team of representatives from Pacific Command, Pacific Fleet, Mid-Pacific Command, Defense Energy Support Center, and Naval Station Pearl Harbor Operations Department. The team was assigned to investigate the resources that were required to maintain the fuel infrastructure. Refueling by tanker trucks was not considered in FISC PH comparative study. It is not an alternative.

A key consideration was that the number of ships home ported today versus the 145 ships in port on December 1941. The infrastructure needed in 1941 was quite different than that required today. In view of this and the 1997 study, the team evaluated the fuel infrastructure and made recommendations to abandon pipelines under Bravo Docks and Kilo 8, 9, and 10.[1] Hotel Pier was studied as well to determine whether to place it and its associated fuel piping in lay-up as well. This decision eventually led to questions of infrastructure balance, based on the reduced pipeline and associated tasks, which also had political ramifications.[2]

In 2000, the Navy decided to outsource the FISC Fuel refueling work (included operations and preventive maintenance tasks performed by civilian service workers) to Trajen, Inc.[3] An A-76 study was undertaken at the Defense Fuel Support Point (same as FISC PH) that affected 45 ship-refueling workers. The A-76 study was required due to the impending privatization of the civil service workers' jobs. In 2000, Representative Neil Abercrombie of Hawaii's 1st Congressional District won the battle to protect his constituents' jobs. In October 2000, the Navy made a decision at the Secretary of the Navy decided to forgo the A-76 study. This reversed an earlier decision to contract out

[1] Santo Salvo, John LCDR. "Bravo Docks Fuel Infrastructure". Point Paper dated 22 Jan 01. FISC PH Code 700/9540
[2] Binder, J.E. LCDR. "Findings and Recommendations of FISC PH Sponsored Infrastructure Reduction Study Group Formed In Response To Triennial Command Assessment Finding PH1-PH". Memorandum dtd 19 December 1997. Actual assessment occurred from 12 to 21 May 1997.
[3] Trajen, Inc. http://www.contracts.ogc.doc.gov/cld/rd/gao/2000/B-2843102.html

to Trajen, Inc. This decision ensured that no A-76 study would be performed for 5 years.[4] At this time, the A-76 is not available.

In 2002, it was recommended by FISC PH to complete a follow on study that would show current costs and benefits of barge refueling and pipeline refueling and the alternatives and combinations associated with each.

[4] http://www.house.gov/abercrombie/mil.tragen2.htm. "U.S. House of Representative Neil Abercrombie Finalizes Win in Fight to Protect Pearl Harbor Jobs" October 23, 2000. House of Representatives.

II. INTRODUCTION

A. COST BENEFIT ANALYSIS OBJECTIVE

The cost of refueling via a barge or a pipeline at a pier or wharf at the Fleet Industrial Supply Center Fuel Facility at Pearl Harbor is the focus of this cost benefit analysis. The steps of the cost benefit analysis used in this study were taken from the book, *Cost-Benefit Analysis: Concepts and Practice* by Anthony Boardman, et. al.[5] The results of this study may provide insight to FISC PH about which method or combination of methods are best suited (cost/benefit maximized) for future operations. The alternatives are (1) the status quo of refueling using a combination of barges and pipelines, (2) refueling via pipelines only, and (3) refueling via barges only. Analysis of these alternatives will highlight financial consequences that will allow Port Operations, Defense Energy Support Center, and FISC PH to make decisions concerning the allocation of funds for future Military Construction (MILCON) and Military Repair and Environmental (MRE) projects.

B. GENERAL INFORMATION

Fleet Industrial Supply Center Fuel Department at Pearl Harbor provides refueling services using pipelines from wharfs and piers and using barges filled from piers. Fuel is provided to fleet units (aviation, surface, and subsurface) and shore activities. Over three of the last five years, FISC PH has issued an average of 1,183,000 barrels (multiplied by 42 equals 49,686,000 gallons) of Diesel Fuel Marine (DFM).[6] The Fuel Department supports every branch of the military service, plus foreign vessels. The facility supports Hickham Air Force Base, Kaneohe Marine Corps Base, and neighboring islands (for example, the Johnston and Kwajalelein Islands).[7] FISC Pearl Harbor receives fuel products from commercial contracted tankers that deliver as scheduled by the Defense Energy Support Center. The main deliveries included JP-5 to Kaneohe, JP-8 to Hickham and DFM to surface fleet units. These units consist of transient vessels to

---

[5] Boardman, Anthony, etal. Cost-Benefit Analysis: *Concepts and Practice, Second Edition.* New Jersey: Prentice Hall, 2001.
[6] Santo Salvo, John. Fleet Industrial Supply Center Pearl Harbor, Hawaii Self-Appraisals for 1999, 2000, and 2001 American Petroleum Institute (API) Award.
[7] Santo Salvo, John. Fleet Industrial Supply Center, Pearl Harbor Hawaii Self-Appraisal for the 2000 API Award. January 2001. pg. 3.

and from 6-9 month deployments, units involved in naval and joint exercises, and forward deployed ships in Hawaii.

Of the three fuel products, DFM delivery alternatives and its infrastructure are the focus of this cost benefit analysis. The common fuel for comparing the refueling methods will be Diesel Fuel Marine (known as F-76), stock number 9140-00-273-2377.[8] How can Diesel Fuel Marine be delivered the most efficient manner, given a dynamic fleet mix, at the most effective cost with the limited resources available? This cost benefit analysis purpose is to provide insight that will help decision makers assess options for the future.

Discussion of refueling procedures in general will provide insight about the variables associated with the alternatives and costs of each delivery system. The costs of refueling an anchored ship via a barge verses refueling a ship via pipeline berthed at a pier or wharf will then be compared in this study. Considerations in cost benefit analysis associated with the barge include the need for a prime mover (tug), double handling of fuel, and the difficulty in isolating a major rupture of barge piping or tanks. Considerations for pierside refueling include the single handling of product with reduced manpower, the isolation characteristics, and high capitalization costs.

The impetus behind this study is identifying the costs and benefits of each method (and a combination of methods), which could lead to future savings for the Fleet Industrial Supply Center at Pearl Harbor.

C. REFUELING 101

1. Underway Replenishment

Most vessels use this option to alleviate environmental and quality of life issues associated with barge and pipeline refueling in port. The fleet is very experienced at underway replenishment and takes advantage of this option prior to entering port regularly. It is popular with the personnel onboard ships, because it alleviates manpower and watches associated with refueling evolutions in working and liberty ports. It also reduces the probability of spills in harbors. If there is no need to refuel in port, then the probability of a spill and the manpower associated with refueling is zero. Ships try to

[8] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002.

top off at sea as much as possible to avoid these potential problems. However, prudent Commanding Officers will top off their ships prior to leaving port, even though the quantity needed may be small. There is a smaller probability of a spill, if smaller quantities are needed pier side and from the barge. Time, costs, and risks are reduced when utilizing underway replenishment vice pierside and barge refueling. However, all refueling evolutions cannot be accomplished underway. Truck deliveries of small (< 10,000 gallons) quantities of fuel to submarines and smaller, local watercraft are modes that serve a good purpose, but will not be considered in this study.

2. Pierside Refueling

Pier side and barge refueling of fleet vessels receiving large volumes of fuel play a vital role in supporting fleet operational readiness. Under normal procedures, pier side refueling is requested via an official Naval message (Logistics Requests {LOGREQ}) or correspondence to the Fuel Department. When there is a contingency or emergent requirement, a phone request or email request (followed up with an official priority naval message) is sent delineating the ship's requirements. Port Operations and the Fuel Department coordinate to schedule resources in order to provide the fuel. Hotel Pier is Pearl Harbor's primary fueling pier.[9]

Given normal circumstances, the customers (mainly cruisers, frigates, and destroyers) state the quantity and type of fuel that is required in an official naval message. Additionally, any amplifying instructions are included such as pipe flange sizes (for example, standard NATO fittings), time requested, environmental issues, and safety precautions. The message process is the initial phase of actual delivery service.

In the event of exercises such as RIMPAC, Defense Energy Support Center, Hawaii Region facilitates exercise requirements well in advance based on historic data and fleet unit requests.[10] Conferences and meetings are held in advance of major

[9] Commanding Officer FISC PH. Customer Service Guide. FISC PEARL INSTRUCTION 4400.IQ.
[10] http://www.cpf.navy.mil/rimpac2000/RIMPAC 2000. Description of RIMPAC exercise by Pacific Command. 2000. RIMPAC is an exercise designed to enhance the tactical capabilities and cooperation of participating nations in various aspects of maritime operations at sea. The exercise involves land- and carrier-based aircraft, amphibious and ground forces, surface combat, support and amphibious ships and submarines. In 2000, more than 50 ships, 200 aircraft and 22,000 Sailors, Airmen, Marines, Soldiers and Coast Guardsmen were involved in this regularly scheduled exercise. "Maritime forces of Australia,

exercises to coordinate and address issues with the fleet and FISC, Pearl Harbor. These issues include fuel exchange agreements, costs, interoperability of refueling systems, operational risk management, “nuances”, and dynamic issues.

The next step in the refueling process is determining how to deliver the fuel to the customer based on pier load, harbor traffic, assets’ availability, and the customer desires. Pearl Harbor, Hawaii has “99 berths inside the channel, with 29 being assigned to the Naval Station, 32 to the Naval Shipyard, 14 to the Submarine Base, and 19 to FISC Pearl Harbor.”[11] The fuel loading focus is at FISC PH, where the refueling assets are located. There are thirty-three ships home ported at the Pearl Harbor.[12] Based on their operational tempo and exercises, pier-berth loading for refueling must be planned, prioritized, and assessed to ensure all customers are serviced.

One of the major industries in Hawaii is tourism. The number of people visiting and touring affects the traffic in the harbor and channel. Cargo vessels and other private tankers delivering to the Navy and other commercial entities must also be considered.

Port Operations and Port Authority communication is essential for making a determination of when, where, and how to refuel a customer using the assets available at a given time. After determining time, place, and method, resources are committed to the refueling process. Those allocations include tugs, manpower, equipage, and infrastructure. Tugs are used to move vessels to the berth assigned for refueling. Pier side refueling requires three to six personnel of which two represent sunk costs associated with standing watch in a tunnel and at Red Hill to facilitate refueling and safety 24 hours a day, seven days a week.[13] Once the vessel is placed at a berth, environmental oil booms are deployed around the ship to contain any spills in the event of an accident. Engineering and supply personnel communicate and coordinate more specific details such as sampling requirements, flange and connector sizes, adapters, and administrative

---

Canada, Chile, Japan, the Republic of Korea, the United Kingdom and the United States of America participated from 24 June - 22 July 2002.

[11] http://www.globalsecurity.org/military/facility/pearl_harbor.htm Pike, John. Pearl Harbor. Global Security. 9/27/02.

[12] Naval Station Pearl Harbor website.

[13] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

and payment obligations. The priority of refueling is determined by Port Operations and FISC PH based on asset availability and the urgency of need.

Customer desires are addressed in official naval message. The customer requests quantities, then Port Operations and FISC PH determine the delivery modes (barge or pipeline via pier).

3. Barge Refueling

Fuel personnel assigned to FISC PH and Port Operations perform barge refueling. The customers include destroyers, frigates, and cruisers. One tug is required to move the barge alongside the vessel. Four barges are assigned to Pearl Harbor. Four (YON 273, 274, 281, and YON 289) are used for refueling and 5 SWOBs (Ships Waste Off-loading Barge) are used to facilitate ships' maintenance or decommissioning.[14] Two of the four refueling barges will be used for this cost benefit analysis. YON 273 is 165 feet and 1195 tons with a draft of 8 feet. YON 281 is 166 feet and 1239 tons with a draft of 9 feet.[15] Each barge has a capacity of 360,000 gallons and requires three personnel (one E-6 in a supervisory/safety role and two E-5 operators) to complete the actually barge refueling function.[16]

In both barge and pipeline refueling, a picket boat is used for the deployment of containment booms around ships. The refueling team fills the barge from the pipelines and fills the ships from the barge. This double handling of fuel impacts the overall costs of the evolution and will be addressed in the study. Booms are deployed, secured, and redeployed at the final anchorage determined in advance by Port Operations.

Upon completion of the refueling evolution, the barge is then taken to a designated berth for refill for future requirements or for maintenance as needed.

---

[14] Garrett, Gregory. Fleet Industrial Supply Center Deputy Fuels Officer, Naval Station Pearl Harbor. Email interview with LCDR Roy Drake. NPS, Monterey, California, 9 June 2003.
[15] http://www.nvr.navy.mil/nvrservicecraft/details/YON273.htm and for YON281 and YON289 http://www.nvr.navy.mil/nvrservicecraft/details/YON274.htm Fuel Oil Barge descriptions.
[16] Earhart, Frank LT. Naval Station Pearl Harbor, Hawaii Port Operations Officer. Telephone interview with LCDR Roy Drake. NPS, Monterey, California, 5 January 2003.

THIS PAGE INTENTIONALLY LEFT BLANK

III. METHODOLOGY

A. STEPS AND ELEMENTS

1. This section discusses the methodology, including data collection, definitions, and assumptions associated with the cost benefit analysis of refueling options at FISC PH. It further identifies the steps of the cost-benefit analysis including the following: (1) Alternative projects, (2) Whose benefits and costs count, (3) Impacts and units of measure, (4) Impact over the life of the alternatives, (5) Dollar values of each alternative, (6) Discounting benefits and costs to obtain present values, (7) Computing NPV of each alternative, and (8) Recommendation based on NPV and sensitivity analysis. Ship captains and engineers, shore commanders, and the fleet commanders could benefit from decisions made by Port Operations and the Fuel Manager, based on the costs of refueling evolutions.

B. DATA COLLECTION

1. Barge Costs

a. Average Annual Preventive Maintenance Costs of Barges were collected from Port Operations. The data obtained was based on costs accumulated over the past three years. This variable is defined and considers all elements of costs, including the labor costs of the military personnel. In the 1997 study, labor costs were not included, but are significant contributors to overall cost.

b. Average Annual Corrective Maintenance Costs of Barges were collected from Port Operations. The data included the periodically scheduled overhaul costs every four years and the annual corrective costs. It is assumed that each barge will have a major overhaul every four years as scheduled. Military personnel also perform this overall.

c. Environmental Protection/Prevention Costs include the costs to deploy environmental containment booms around barges and vessels being refueled. This procedure requires two personnel deployed in a small boat from rates varying from E-2 to E-7. In this study, the baseline rate used was the average of an E-5 and an E-6. The costs in this area are based on the average of refueling evolutions per month and the pay scale for military members.

d. Environmental Corrective Costs are based on data obtained over the last two years from Port Operations and FISC PH. The annual costs associated with spills were obtained from material costs and clean up costs including labor and time.

e. Operational Costs of barges include the tugs needed to tow and set barges, the manpower used to accomplish assigned tasks, and the accumulative time expended in completing evolutions.

2. Pier/Pipeline Costs

a. Average Annual Preventive Maintenance Costs of pipeline include valve and pipeline maintenance of a 57-year old piping infrastructure. This also includes cleanliness directly associated with the pipeline to minimize corrosion.

b. Average Annual Corrective Maintenance Costs of pipeline include emergency repairs and renovation military construction projects. This figure will be an estimated figure based on historic data and actual military construction costs. The most recent project cost to bring Hotel pipeline services back on line was $1.8 million.[17] Other pipeline projects ongoing in 2003 are the repair of Bravo docks and pipelines at a cost of $10,490,000.00 for 10 years of service, equating to $1.05 million per year.[18]

c. Environmental Protection/Prevention Costs are those costs associated with the time and manpower to deploy environmental booms around ships that are being refueled.

d. Environmental Corrective Costs of pipeline are the average costs associated with spills over the last two years as provided by Port Operations.

e. Operational Costs of pipeline are the costs of refueling evolutions, including valve lineups and safety monitoring. The Hotel Pier pipeline operational cost depends on the number of evolutions per month. This infrastructure delivers 10,000 barrels per hour via two 8-inch hoses attached to the pipeline risers.[19]

---

[17] [17] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

[18] http://www.defenselink.mil/news/Feb2002/d20020204mc.pdf

[19] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

The average labor cost of one refueling evolution is $291.48.

3. Alternative Projects

a. Alternative One: The status quo is refueling using a combination of barges and pipelines services.

b. Alternative Two: Exclusive pipeline use.

c. Alternative Three: Exclusive barge use.

4. Who has standing?

a. Political representatives and elected officials clearly have standing and protect their constituents regardless of cost efficiencies. As noted in Section I, Background, significant decisions can be reversed based on non-cost justification.

b. Civil service ship fuel workers.

c. Military members of the barge crews.

d. FISC PH (including the Fuel Manager and Commanding Officer).

e. Secretary and Undersecretary of the Navy.

f. Ships' Commanding Officers and Engineering Officers. (Some submarines are refueled by trucks and were not considered in the study).

5. Impacts and Measurement Indicators

Impacts and measurement indicators are shown in Table 1 for the alternatives considered in the CBA. Costs associated with each option were defined in sections B.1 and B.2. Each benefit was derived from the time and money saved as compared to other methods of refueling. For example, the rate that a ship can receive fuel depends on the class and storage tank capacities.

Barge and pipeline delivery rates vary as well. Barge delivery capacity is limited much more than pipeline capacity. Any of the Fuel Facility's pipelines can accommodate any U.S. Navy vessel's capacity. Bulk fuel tanks can be aligned and realigned, as fuel is required. However, a barge holds a limited capacity of 360,000 gallons of fuel and is better suited for smaller vessels or larger vessels requiring small amounts of fuel. "The

most common mode of issue for fuel is by pipeline, although ships berthed second outboard from the pier will normally receive service via barge".[20]

a. **Time** is crucial when ships are operating in exercises and are on a tight schedule in order to meet assigned tasks and missions. A ship's Chief Engineer is highly concerned with the refueling lineup and his or her department performs a valve line up twice to ensure that fuel is ready to be received. The military crew and civilian service personnel perform the same checks on the barge and pipeline, respectively.

The time that it takes for the Fuel Farm crew (3 civilian service personnel) to line up a 20" pipeline at Hotel Pier to distribute fuel to a receiving vessel is between 20-30 minutes. In this study, the baseline is 25 minutes. The receiving time varies based on the amount of fuel required by customers. The Fuel Manager provided typical times and costs for refueling destroyers (such as the USS Hopper and the USS Chosin), cruisers (such as the USS Lake Erie), and an auxiliary oiler (the USNS Yukon).

Each approved refueling request by customers is assigned a work order and location. A small sample of typical times and costs are included in Table 2 for refueling ships. From Hotel pier's data sample, which is highly representative of many refueling evolutions as noted during an on site visit to FISC PH, the average time of refueling evolutions (excluding set up and securing times) is a little over 14 minutes at a average cost of $291.48. Securing the system takes an additional 20 minutes. The data provided and included in the table does not account for an aircraft carrier, which would increase the figures. However, aircraft carriers refuel from Pearl Harbor much less frequent than the home-ported smaller ships (cruisers, destroyers, and frigates). For typical evolutions, the total time expended in servicing a ship of the size of a T-AO or smaller is 25 minutes (set up) + 14 minutes (average refueling time) + 20 minutes (secure time). One hour is the typical time for 1-time (1 x) handling of equipment to execute normal refueling top offs and meeting the mission needs of local customers from Hotel pipelines.

The Port Operations' military boat crews are required to deploy environmental booms around ships prior to the refueling workers executing refueling

[20] Commanding Officer FISC PH. FISC PEARL INSTRUCTION 4400.IQ.

evolutions. The deployment time varies from 30-45 minutes depending on the ships size. The time required to remove the boom was approximately 30 minutes. In this study, 30 minutes is used as a baseline.[21]

The total time for refueling a typical ship on a typical day is two hours from preparation until retrieval of environmental protection equipment. The time described is for a ship refueling moored to a pier with a pipeline riser available for distributing DFM.

In the event that a ship is anchored in the harbor or berthed outside of another ship or two, the barge is used. This alleviates hoses draping and running across multiple ships' main decks. However, it generates another problem for refuel workers and military barge operators: double handling of fuel that adds more time to the tasks. Instead of two hours, the time could increase as high as four. This includes the time that it takes for a tug operator to secure and move the barge to its destination next to a receiving ship. The tug hourly rate is $326.17 with a premium charge for overtime of $506.17. Once the tug tows the barge at its refueling position, the military crew from Port Operations re-booms the ship and barge to prevent spread of DFM into the harbor in the event of a spill. Port Operations provides an additional person (as the safety supervisor for the refueling evolution) to assist the personnel that deployed the boom. For barge refueling, three civilian service personnel from FISC PH, a tug, a loaded barge, a small boat, and three military members of Port Operations are required. Time grows as pier side refueling is move to barge refueling.

The time for 1 x is two hours and the time for 2 x is four hours. In this study, simultaneous pipeline and barge refueling is assigned a 3 x handling evolution that equates to 6 hours. The times also include the ship's refueling crew set up times. The multi-handling of DFM exacerbates the environmental risks by increasing the probability of a spill occurring.

b. Environmental Impact or Release was not considered in the

[21] Earhart, Frank LT. Naval Station Pearl Harbor, Hawaii Port Operations Officer. Telephone interview with LCDR Roy Drake. NPS, Monterey, California, 5 January 2003.

1997 Triennial Review, but is reviewed in this study. The risk associated with refueling operations in the harbor is not trivial and must be accounted for. Historically, spills have added to the refueling costs. "COMNAVBASEPEARLINST 5090.1 requires the ship or activity responsible for the spill to report by message as soon as possible after the spill occurs or is discovered".[22]

The Coast Guard also patrols local waterways and is sensitive to any oil sheen, no matter how minute. The Port Operations Spill Response Team is funded with 16 military billets operating 12 boats with an E-7 in charge. Some of this cost is indirect since the team has other duties and the boats are also used to deploy booms. However, the costs of the team existing and performing work on the boats and executing training adds to the environmental costs. It is assumed that in a given day 7 of the 16 military personnel between E-2 and E-7 are involved with environmental issues associated with supporting the barges.[23] For the study, this portion of the environmental cost will be based on 7 E-4's (an average of three years experience) with annual compensation of $34,370.00 each. This cost takes into account the statement of work and hours of service provided in section C of the Onsite Spill Response Team (OSOT).[24] The total annual cost of the team's impact on barges is $240,590.00.

FISC PH fuel workers oversee environmental issues associated with pipelines. A portion of the cost associated with ordering supplies and preparing for spill response must be accounted for. It is difficult to capture the costs of patrolling, reporting, and completing the preventive and corrective actions performed by each activity if DFM is released into the harbor. The documented spills indicate relatively small costs over the past few years. As of January 2003, there have been 20 spills totaling approximately 70 gallons (3.5 gallons/spill) over a two-year period. The cost of clean up and associated reporting is $20,000.00 per year.[25] The U. S. Navy has not caused a harbor-impacting spill; however, the risk of catastrophic barge failure or pipeline failure cannot be

---

[22] Commanding Officer FISC PH. Customer Service Guide. `FISC PEARL INSTRUCTION 4400.IQ.`

[23] Earhart, Frank LT. Naval Station Pearl Harbor, Hawaii Port Operations Officer. Telephone interview with LCDR Roy Drake. NPS, Monterey, California, 5 January 2003.

[24] http://www.msc.navy.mil/N10/pearl/sow.doc Pearl Harbor Oil Spill Onsite Team (OSOT) services noted in Statement of Work.

[25] Earhart, Frank LT. Naval Station Pearl Harbor, Hawaii Port Operations Officer. Telephone interview with LCDR Roy Drake. NPS, Monterey, California, 5 January 2003.

disregarded. A barge failure would be harder to isolate, but would probably release less content if a pipeline failure was unable to be isolated.

For example, on May 14, 1996, Chevron had a pipe rupture that released 982 barrels of fuel oil into the waters of Pearl Harbor, which caused the closure of the entire harbor.[26] This was a rare occurrence, but the monetary costs and physical damage were devastating. Environmental factors must be considered. Costing them is the challenge.

To account for environmental corrective costs, the probabilities of a spill occurring must be addressed. The baseline will take into account the reported spills over the last two years as noted previously in this section. Over the 10-year life of the pipeline, 10 spills are estimated to occur every year. There is a ten percent chance of a spill occurring for a pipeline refueling evolution, a twenty percent (due to double handling of the fuel) chance for a spill occurring for a barge refueling evolution, and a thirty percent chance for a spill occurring during multi-operational (barge and pipeline) refueling. At a cost of $20,000.00 per year, the pipeline environmental cost will be $2,000.00 (.10 X 20,000), the barge's is $4,000.00, and the combination of the two is $6,000.00.

c. Renovation: In this study, the cost of renovation via military construction or military, repair, and environmental projects will be compared to the cost of a barge overhaul. Since new barges and new pipelines are not planned in the future, capitalization costs are less accurate, while the costs to overhaul barges and the costs to complete major corrective pipeline repair are more appropriate for the CBA. Although this is the direction of the study, capitalization costs of a new pipeline would be in the range of $30-35 million dollars.[27] A barge would cost about less than ten percent of that figure.

The estimated cost to overhaul (CM-corrective maintenance) the refueling barges is + $900,000.00 each. The preventive maintenance cost is estimated at $112,500.00 per year per barge. The preventive maintenance (PM) does not include the

[26] www.chevron.com Chevron Pipeline Oil Spill. NOAA. 3/22/02.
[27] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

manpower costs. Manpower cost is derived from estimated time spent performing PM on the barges. This cost is based on 3 E-4's performing maintenance throughout the year. The cost assigned is 3 X $34,370.00 = $103,110.00 per year.[28] Barge PM is assigned a value of $112,500.00 + $103,110.00 = $215,610 per year per barge. Barge CM is +$900,000.00 per 4 year period, thus $225,000 spread out annually.

d. Environmental Boom Deployment employs two military members of the Spill Response Team to execute spill containment functions for refueling evolutions. An E-4 and E-5 military compensations (for 6 years in the service) averaged together makes up the manpower cost of boom deployment. $36,305.00 and $$40,666.00 averaged is $76,971.00/2 or $38,486.00 per year. The boom takes 30 minutes to deploy and 30 minutes to retrieve.

e. Readiness and Customer Service are impacts that affect quality of life as well. Refueling from a pipeline is usually faster in most instances than a barge. The faster the evolution progresses, the less likely a spill will occur in a given period, and the quicker troops can go on liberty. This may seem trivial, but if personnel are not concentrating on the task at hand, spills can likely occur. Mistakes occur. The barge refueling allows a customer to take on fuel at vantage points that may not be appropriate at the pier during a period of congested docks.

Flexibility and the cooperation between Port Operations and FISC PH as observed benefits customers and saves time. Optimizing barge refueling for smaller ships and submarines and using pier for larger vessels for pipelines keeps control of traffic during peak refueling periods. RIMPAC is an example of this with an average of 840 transient ship days (days that non-home ported ships are in port Pearl Harbor) per year. In the out RIMPAC years, it has been 360 days per year.[29]

One con of the barge is that it requires a power driven vessel to tow it to its destination. The pier requires no tug.

f. Class of Ships used in the study were cruisers, T-auxiliary oilers, destroyers, and frigates. These were the most consistent customers, mainly due to most

[28] Earhart, Frank LT. Naval Station Pearl Harbor, Hawaii Port Operations Officer. Telephone interview with LCDR Roy Drake. NPS, Monterey, California, 5 January 2003.
[29] Sykes, Keith. LCDR. FISC Customer Service Officer. "Transient Ship Days" Email to Charles Race dtd 8/13/02.

are home ported there. An aircraft carrier would not be appropriate as a barge customer. Based on contingencies and harbor traffic, U.S. Navy ships wanting service are placed at berths based on their request dates and arrival times. A combination of pipeline and barge allows a ship to take on fuel from both sides of the ship. The combination also allows multiple ships refueling at the same time.

Table 1 illustrates some impacts and measure indicators. It provides some insight to some of the items of concerned when the FISC Fuels Manager is looking at refueling options. It also delineates items that may have been overlooked or defined differently in the previous study.

The items provide stakeholders with a number of impacts to be considered. Assumptions and definitions are delineated in section B.5. Cost data is provided for follow on CBA.

6. The Future Impacts of Pipeline and Barge Refueling

Future impacts will continue to be beneficial to end users of DFM. Flexibility and refueling efficiency help maintain ships in a high state of readiness. Each option adds directly to customers' benefits. Whether bringing an idle pipeline back into service or moving a barge to a ship, each alternative has beneficial attributes aimed at supporting the war fighter.

The unpredictable schedules of ships requiring fuel make future forecasting usage quite difficult. However, past quantities and future scheduled exercises help estimate future demands. For instance, RIMPAC is a biennial exercise and by averaging the figures of the last three, an estimate can be made of the future benefits as well. In the most recent RIMPAC, 129,719 gallons were issued.[30]

a. Barge refueling can provide up to approximately 360,000 gallons (all fuel can not be exhumed from the barge tanks, but 360,000 is the number that is used to indicate full capacity) to each vessel that it services. It allows refueling flexibility when the harbor is traffic laden, due to tourism or exercises. It allows refueling capability to be mobile and go to the customer, vice the customer coming to the pier. The

[30] Garrett, Gregory. Deputy Fuel Director FISC PH Fuel Facility. Email dated 6/6/03. Subject-Re: Data request.

two refueling barges at FISC PH can be used to top off two different vessels at the same time.

Ideally, each barge will undergo an overhaul every four years at a cost of $900,000.00. Historically, barge overhaul are usually every 5-6 years.[31] With this in mind, in this study, every 5 years will be used as the overhaul periodicity. During the years where an overhaul is not required, $158,006.00 is required for military personnel to maintain the barges. This total cost includes military compensation, maintenance, and material costs. For a 10-year period, barge total maintenance is expected to be well over 2.8 million dollars in current dollar terms.

Barges provide Diesel Fuel Marine (DFM) that allows ships to operate. For 360,000 gallons, the average ship of the size less than an aircraft carrier will be able to travel 12 days after being refueled by a barge. This is assumed that a ship takes all of the barge's content (highly unlikely) and a standard consumption rate of 80 gallons per hour. This equates to 4,500 nautical miles, but due to ambient losses and other variables, 4,000 nautical miles were used. As ships become more fuel efficient, this benefit will increase.

b. Pipeline refueling provides customers with virtually unlimited fuel at higher flow rates in the delivery mode. For smaller vessels using four-inch hoses, the flow rates vary from 60,000 to 70,000 gallons per hour. Two eight-inch hoses deliver 420,000 gallons per hour from the pipeline. This is a common configuration for large loading plans. For 6" hoses, the flow rate is approximately 100,000 gallons per hour.[32] Table 2 identifies the benefits (fuel provided) and costs associated with a typical period of refueling at FISC PH Hotel Pier.

7. Monetized Impacts

The monetized impact include the time that is saved when a pipeline is used to refuel vessels. The time expended towing a barge to an anchored vessel is 326.17 per hour and 506.17 per hour if it is after 1800. The savings take into consideration the

[31] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

[32] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

barge being towed to and from its destinations. In this study, this cost will be base lined as (1.5) x ($326.17) or $489.26 per hour. This benefit is additive when the pipeline alternative is utilized.

The cost of the fuel issued is monetized as the benefit provided to FISC PH customers. The cost is based on the total gallons of fuel issued. The amount of fuel issued determines how far a ship will be able to travel. The Navy willingness to pay for the additional steaming miles is the benefit.

a. "Transient miles added" value is a positive impact provided by ships from barges and the pipelines. In this study, transient miles added is the average amount of fuel consumed by an average ship (CG, T-AO, FFG, DDG) multiplied by the average cost. The average cost is based on a 5-year price average as delineated by the Navy Petroleum Office in an annual official Naval message.[33] The cost of $0.93 per gallon is assigned as the cost of DFM. This cost is also equal to the Defense Science Board's four-year average of Defense Energy Support Center's standard price charged to services for fuel.[34] The average ship consumption rate of 80 gallons per hour is used. The benefit for one hour that the barge adds to the end user is approximately $74.40 ($0.93 X 80). With a baseline consumption rate of 80 gallons per nautical mile, barges can delivery approximately 4,500 transient miles to a DDG. The transient mile amount is obtained by dividing one barge's capacity of 360,000 gallons by 80 gallons. The consumption rate and transient miles added figure can vary based on the intensity of a ship's operation tempo. Conservatively, for this study, 4,000 transient miles will be used taking into account that ships do not travel in straight line distances, fuel ambient losses, and fuel ullage (fuel that can not be exhumed from a barge or shipboard service or storage DFM tank). The benefit is the gallons of fuel issued to the customer, which is measured by the cost of fuel issued. This benefit is taken to be the Navy's willingness to pay for additional steaming miles. Therefore, at $74.40, barges could provide a benefit

[33] www.navpetoff.navy.mil/documents/ FY03%20Bulk%20Petroleum%20Standard%20Prices.doc, www.navpetoff.navy.mil/documents/ FY02%20Bulk%20Petroleum%20Standard%20Prices.doc, and www.navpetoff.navy.mil/documents/ FY01BulkPetroleumStandardPrices.doc. NAVPETOFF FT BELVOIR VA. Annual petroleum messages. Fort Belvoir, VA.

[34] http://www.acq.osd.mil/dsb/fuel.pdf Schneider, W. Chairman, Defense Science Board. "More Capable Warfighting Through Reduced Fuel Burden." January 2001. pg 15.

of $334,800 to a ship per refueling evolution. In this scenario, it is assumed that all ships requiring service from the barge will take full loads. History has shown that the each barge makes an average of 53 deliveries per year, providing an average of 5,632,629 gallons per year to customers.[35] Given an average fuel price of $0.93, $5,238,345.00 of benefits is provided by one barge and two barges provide $10,476,689.00 per year. Pipelines provide benefits based on the number of gallons and time of the evolution.

b. Transient days: Based on Table 3, the combined average daily fuel consumption rate for selected ships (this study used a combined CG, FFG, and DDG average) is 30,030 gallons per day.[36] A barge provides a benefit of 12 days of steaming to the warfighter. The Navy is willing to pay for this benefit.

8. Discounting Benefits and Costs To Obtain Present Values

a. Terms and Formula Description:

PV (C) is the present value of Costs: PV (C) = "A cost in a given year is converted to its present value by dividing it by $(1+s)^t$, where t is the given year and "s" is the discount rate. PV (C) = the summation of $(1+s)^t$ based on the number of years of the life of the barge or pipeline at a given time."[37] As in the 1997 study, barge and pipeline preventive and corrective maintenance will be used to compute costs.

b. Additional Considerations: In addition to these costs, environmental and operational costs will be used in computing the overall benefits of each alternative.

9. Net Present Value (NPV)

NPV is computed by taking the difference between the PV of benefits [PV

[35] Binder, J.E. LCDR. "Findings and Recommendations of FISC PH Sponsored Infrastructure Reduction Study Group Formed In Response To Triennial Command Assessment Finding PH1-PH". Memorandum dtd 19 December 1997. Actual assessment occurred from 12 to 21 May 1997.

[36] http://www.fas.org/man/gao/nsiad98001/a3.htm Navy Aircraft Carriers. Cost-Effectiveness of Conventionally and Nuclear-Powered Aircraft Carriers. GAO/NSIAD-98-1 -- August 1998. Table III.2

[37] Boardman, Anthony, etal. Cost-Benefit Analysis: *Concepts and Practice, Second Edition.* New Jersey: Prentice Hall, 2001

(B)] and the PV of costs [PV (C)]. In this CBA, this equation is key to recommendations and conclusions. According to Boardman, if there are multiple mutually exclusive alternatives, pick the one with the highest NPV.

10. Sensitivity Analysis will address the impact of environmental and changing the number of assets and how they impact operations. Surges during operations and exercises can be addressed through additional assets. The impact of these asset additions on costs will be analyzed in Section V.

11. Recommendations will be based on Boardman's recommendations of regarding choices of alternatives and personal operational research on and operational management of Fuel Facilities. Recommendations will be provided in Section VI.

Impacts and Measure Indicators	Pipeline	Pipeline/Barge	Barge	Notes
Time	1x handling	3x handling	2x handling	Handling refers to operators connecting hoses to connections and setting up refueling evolutions.
Release of Diesel Fuel Marine to the environment.	Less chance of spills to the environment.	Triple the chance of spills to the environment.	Double the chance of spills to the environment.	This risk was not considered in the 1997 study.
Renovation costs*	Renovation is required less than barge overhaul (10 versus 4 years)		Overhaul required every 4 years.	*used renovation costs vice capitalization costs since idle pipelines could be restored close to their original condition.
Environmental boom deployment	Deploy boom once with two military personnel	Deploy boom three times.	Deploy boom twice: once to boom the barge, then again to boom the ship being refueled	Boom deployment requires a two-man crew with radios on a small boat with environmental prevention/cleanup supplies.
Customer Service	Faster and no prime mover needed for refueling evolution. Have a total of 16 refueling risers for DFM distribution.	Allows flexibility for surges and increased operation tempo. Need a prime mover.	Slower than pipeline and carries less capacity. Need a prime mover.	The prime mover of choice is the harbor tug operated by Port Operations.
Readiness	Limited by the number of berths per pier (i.e., Pier hotel-5 berths).	During exercises such as RIMPAC, more ships can be refueled.	This is the most limiting configuration. There are only two barges for refueling	

			evolutions.	
Classes of ships served	Destroyers, Cruisers, Frigates, Auxiliary Oilers, Aircraft Carriers, Amphibious Assault and Amphibious Command,etc.	Destroyers, Cruisers, Frigates, Auxiliary Oilers, Aircraft Carriers, Amphibious Assault and Amphibious Command,etc.	Destroyers, Frigates, small amphibious ships, and Cruisers	The refueling modes are not mandatory for the type of ship shown, but are the most likely option and most flexible in determining service.

Table 1: Impacts and Units of Measurement Indicators

Ship type	Fuel type	Berth (Pier-berth number)	Time (Minutes)	Labor Costs (actual $)
CG	DFM	H2	8:05	184.03
DDG	DFM	H2	7:50	156.57
DDG	DFM	H1	10:37	160.43
DDG	DFM	H3	6:35	112.11
DDG	DFM	H3	7:28	122.84
T-AO	DFM	H2	18:36	408.07
T-AO	DFM	H2	16:15	401.00
T-AO	DFM	H2	18:17	438.29
T-AO	DFM	H3	21:17	466.20
T-AO	DFM	H3	37:11	709.54
CG	DFM	H2	7:27	144.95
CG	DFM	H2	10:23	193.72
CG,T-AO,DDG,	DFM	Hotel pier	Approximately 14:09	291.48

Table 2: Typical Times/Costs Associated With Refueling Ships from Pipeline.[38]

C. COST ELEMENTS

1. Discount Rate

The discount rate of 7% will be used to account for the time value of money. This value was chosen based on the guidance of Office of Budget and Management Circular No. A-94.[39] The Net Present Value (NPV) calculation of the 1997 study included an interest rate of three percent, in addition to the 7%.

[38] FISC PH Samples of Work Order Reports from 6/1/01 through 12/13/02. Provided by LCDR John Santosalvo on 12/27/02 at FISC Fuels Manager's Office.

[39] http://www.whitehouse.gov/omb/circulars/a094/a094.html#7 OMB circular A-94 (Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs). 10/29/92. Transmittal memorandum.

2. Civilian Wages

The salaries used for operators that perform refueling evolutions were taken from the Office of Personnel Management.[40] The civilian wages used in this cost benefit analysis were generated by averaging GS-06 and 08 (fuel operators) at step 6 from Figure 3.

a. Military Wages

The salaries used for military operators that performed refueling and environmental protection evolutions were obtained from the FY 2003 Military Pay and Allowances charts.[41] The E-5 and E-6 military annual compensation for fiscal year 2003 were average to get the military wage figure. The figure used assumes the military compensation at 8 years of service based on research interviews.[42] The source data is from Figure 4.

D. COMPUTING THE COSTS

1. Cost Elements

Barge costs, and pipeline costs were collected and used to compute and compare the costs of each refueling combination. Each alternative's cost was computed and discounted in the same manner. The discount rate used was set at 7%, even though there may have been year-to-year variances of this rate.

In order to capture the cost of each evolution, the costs of tug usage, manpower, environmental boom deployments, and preparation time costs were added together and discounted.

For barge refueling, the double handling of fuel (once to fill the barge and a second time to discharge the product to the end user) will be accounted for by adding the additional time and resources needed to service the customer. This was not accounted for in the previous study.[43]

All of the cost information is noted in Figure 1.

---

[40] http://www.opm.gov/oca/03tables/html/gs_h.asp Salary Tables 2003-GS.
[41] http://usmilitary.about.com/library/milinfo/pay/blenlistedsalary.htm Fiscal Year 2003 Military Pay and allowances. Annual Salary Charts.
[42] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.
[43] Santo Salvo, John LCDR. FISC Pearl Harbor Fuel Director. Interview with LCDR Roy Drake. NPS, Monterey, California. 27 December 2002. Red Hill: DFM bulk storage facility at FISC Pearl Harbor.

DISCOUNT RATE	7%
Tug rate (normal working hours)	$326.17/hr
Tug rate (overtime)	$506.17/hr
Diesel Fuel Marine (DFM) average costs over last 5 years	$0.93/gal
Average Preventive Maintenance Cost per Barge*	$215,610.00/yr
Average Corrective Maintenance Cost per Barge*	$900,000/5yrs $180,000/yr
Barge Refueling Rate	72,000gallons/hr
Average Spill Costs per year	$40,000/yr
Average Spills per year	10/yr
Spills associated with barges per year	6.5/yr
Spills associated with pipelines per year	3.5/yr
E-5 and E6 average annual compensation (1 worker)	$45251/yr/operator
GS 06-08 (average) wage annual pay (1 worker)	$34002/yr/operator
Average Annual Preventive Maintenance Costs of H pipeline	$158,006/yr[44]
Corrective Maintenance Cost of H pipeline	$1.8 million
Refueling handling time via barge	4 hrs
Refueling handling time via pipeline	2 hrs
Simultaneous barge and H pipeline refueling	6 hrs
OSOT costs associated with barge environmental issues	$240,000/yr
Annual boom deployment costs ($38,486.00 X 2)	$76,971/yr
Baseline Gallons Consumed Per Nautical Mile	80 gal/ N.mile[45]
Transient Miles Added per barge issue	4,000 nautical miles
Benefit added by barge	$334,800/barge issue
Benefit per pipeline issue	$74.40/gallon
Benefit in days provided by barge	12 days

Figure 1: General Data * Average includes year 1997-2002.

[44] Recurring Maintenance Costs Associated with Hotel pier pipeline infrastructure for the average costs in the last three years. 2002-$48,000.00; 2001-$72,000, and 2000- $48,000.00 = $168,000.00/3 = $56,000.00. This is added to the 3 civilian service fuel workers required to perform PM of H pipeline @ $34002 each = $158,006.00

[45] This rate is based on evaluating the Full, Split, and Trailing shaft operations of a ship. Assumptions: Navy normal operations and DDGs, FFGs, CGNs, and T-AO's average consumption rate is 80 gal/N.M. The average gallon per nautical mile figure is near or above split plant operations from Figure 6.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. ANALYSIS

A. ALTERNATIVE ONE: PIPELINE AND BARGE COMBINATION

This combination is the status quo and leads to an estimated positive net benefit of $179,752,226.91 over the 10-year life. It allows the most flexibility of the three, but with additional costs. The operational, environmental, and maintenance costs identified in Sections III B and IIIC were all considered in determining the cost and benefits of each alternative. All computations were completed using Microsoft Office 2000 SR-1 Premium Excel functions.[46] Summations and NPVs were used to arrive at final cost and benefit figures.

B. ALTERNATIVE TWO: PIPELINE REFUELING

1. Pipeline Costs; NPV of Pipeline Maintenance: The NPV of the pipeline's net benefit is $176,308,024.61. Table 4 illustrates the preventive and corrective maintenance costs are outweighed by benefits heavily. The net benefits are positive and has a positive NPV.

2. Pipeline Benefit: From recent and historic data, one Pipeline (Hotel 2) delivers 29,564,707 gallons per year to customers for a benefit of an average of approximately $27,495,178.00 per year over the 10-year life.

C. ALTERNATIVE THREE: BARGE REFUELING

1. Barge Cost: NPV of Barge Maintenance: The NPV of Barge Cost was $2,792,709.84 over the 10-year life of the one barge. Two barges cost $5,585,419.68.

2. Barge Benefit: Based on the most recent barge issue data and history, each barge issues an average of 5,632,629 gallons. As stated earlier, one barge provided $5,238,345.00 of net benefits and two provided $10,476,689.00. The barge has a positive NPV of $31,336,324.44 when benefits to ships and costs to maintenance are analyzed over the 10-year period.

---

[46] Microsoft Excel 2000 Premium SR-1 of Microsoft Office Suite. 2002.

THIS PAGE INTENTIONALLY LEFT BLANK

V. RISK ASSESSMENT/SENSITIVITY ANALYSIS

A. ENVIRONMENTAL RISKS

Environmental risk is the ever-present risk when performing refueling operations, whether it is from a barge or from a pipeline. The difference is the probability increases as the number of steps handling fuel increases. In a barge refueling evolution, a tug is deployed twice at an average cost of $489.26 per hour. As denoted in Section 5.b., an average of approximately 10 spills occur every year at a cost of $20,000.00. The highest risk involved in refueling is the configuration used during peak exercises and surge operations. This incorporates the use of pipelines and barges. Environmental costs increase as the number of resources increase. Pipeline refueling, barge refueling, and the combination of each add $2,000.00, $4,000.00, and $6,000.00 to environmental costs. These costs do not address the associated reporting costs.

Due to the uncertainty and variability associated with environmental risks, a Spill Response Team must be deployed in any refueling evolution. The annual cost for this two-person team is $38,486.00 per year and must be accounted for. Members of the team are required. This cost is a result of the necessity for containment in the event of a spill.

As stated in 5.e., time is added as double handling of fuel increases. Spills and the time associated with double handling of fuel negatively impacts net benefits.

B. SENSITIVITY ANALYSIS

1. **Varying Discount Rates** identifies which alternative has the most benefits with the lowest costs, thus providing an optimum combination. The ranking of alternatives did not change as the discount rate was varied. The combination of barge and pipeline refueling is the best alternative with the highest NPV and highest net benefits. The discount rates were varied from 7% to 10% and from 7% to 2%.

a. **NPV of Pipeline Refueling** was $155,635,424.62 using a 10% discount rate, vice 7%. It was $221,332,468.75 at 2%.

b. **NPV of Barge Refueling** was $27,601,098.14 using a 10% discount rate, vice 7%. It was $39,476,878.87 using 2%.

c. **NPV of Combined Barge and Pipeline Refueling** operation at a discount rate of 10% is $158,537,021.81. At 2%, it is $225,926,416.71.

2. Doubling Benefits provide a better insight of the Navy's willingness-to-pay. A fuel cost alone understates the willingness-to-pay for steaming miles. Training, exercises, and operations benefits are not evaluated, but they are indirect benefits. Doubling benefits while leaving the discount rate at 7% results in the same ranking as the baseline calculations. NPV for the combined operations was $393,018,731.57. The barge outcome is $65,465,358.71 and the pipeline outcome is when benefits are doubled $355,445,495.00.

3. Increasing Environmental Costs by a Factor of Ten using the environmental costs as discussed in the Environmental Risk Section V. Part A. Multiplying the barge environmental cost factors leads to the same ranking of alternatives. This adds an additional $20,000.00 to the pipeline costs, $40,000.00 to the barge cost and $60,000.00 to the combination of pipeline and barge cost per year. The NPV for barge with the additional environmental cost per year is $31,035,715.15 and for pipeline refueling was $174, 987,000.93. The NPV for the combination of barge and pipeline refueling was 143,445,597.16.

VI. CONCLUSIONS/RECOMMENDATIONS

From this extensive research, the conclusions are highly robust and provide an in-depth look at the costs and benefits of FISC PH refueling capabilities.

A. CONCLUSIONS

1. Alternative One

The status quo, combined pipeline and barge refueling, is the best alternative for refueling ships, based on empirical results of the Cost Benefit Analysis. It provides the most flexibility to a group of ships such as those needing fuel during RIMPAC. This alternative had the best net benefits and the highest NPV.

2. Alternative Two

Refueling by a pipeline had the second highest NPV and was the number two choice for refueling benefits. Pipeline capitalization and maintenance costs did not lower the pipeline ranking, when compared with the barge refueling. The pipeline corrective and preventative maintenance costs on pipeline benefits did not affect the outcome as much as the barge's environmental and handling costs had on barge benefits. Additional costs associated with the double handling of fuel and increase in environmental risks has an impact on cost. Empirical results suggest that the pipeline be used in single refueling evolutions; however, if a ship is already berthed at anchor, it should refuel from the closest available means, which may be a barge.

3. Alternative Three

The barge was the last resort for refueling based on the results of the CBA. As stated previously, even with doubling benefits and varying the discount rates, barge refueling had the lowest net benefits and the lowest NPV of the three alternatives. The costs associated with double handling of fuel had a negative impact on the NPV and net benefits. Based on the analysis, barge refueling is the least preferred method.

B. RECOMMENDATIONS

1. Alternative One

I recommend that FISC PH maximize the use of the combined barge and pipeline configuration, refueling a higher percentage of ships from the pipeline. From this CBA, I recommend a 70-30 pipeline-barge split to maintain operational efficiency

and maximize flexibility in the harbor during peak load periods.

2. Alternative Two

Refueling by pipeline as often as possible to reduce the effects of double handling of fuel and the reduced risk for spills into the harbor. The indirect costs of a spill (reporting and notification procedures) make this option even more viable than barge refueling. I recommend building infrastructure that allow flexibility and safety during refueling evolutions at the most cost efficient manner. The pipeline is a good candidate for military construction or renovation project submissions.

3. Alternative Three

I recommend barge refueling be used to supplement pipeline refueling during peak periods. All three alternatives have pros and cons that were discussed and should all be considered in each situation; however, presents the largest potential risk of a spill.

In closing, the ranking chart is a starting point, but not the end all. It is recommended that all external and internal pressures that can affect a refueling operation be considered, prior to making a decision based purely on cost and ranking. In the fiscal environment of today, the Cost Benefit Analysis is a powerful tool in considering whether benefits justify costs.

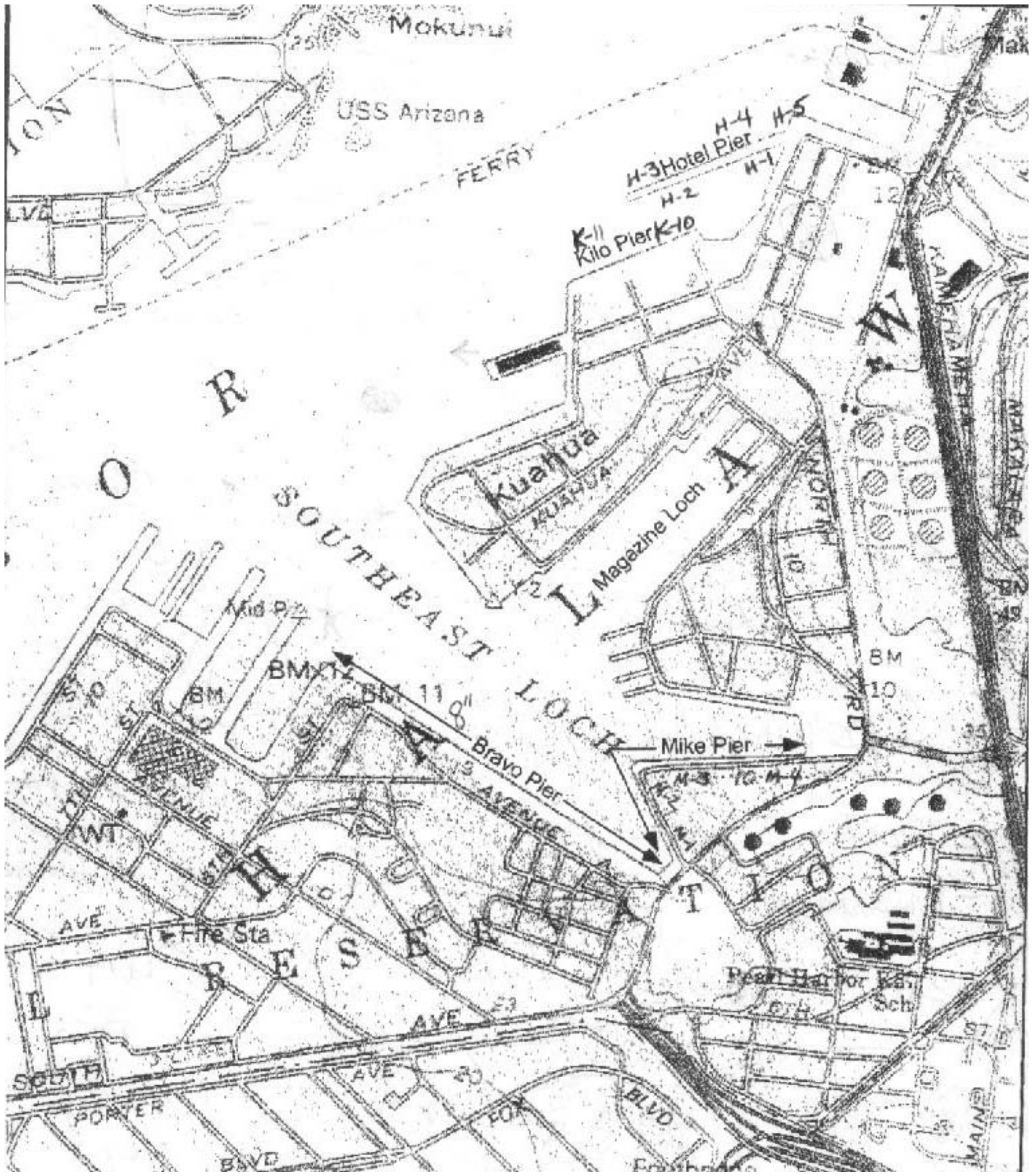

Figure 2: Pearl Harbor FISC Fuel Facility Port Layout

GS	1	2	3	4	5	6	7	8	9	10
1	15214	15722	16228	16731	17238	17536	18034	18538	18559	19031
2	17106	17512	18079	18559	18767	19319	19871	20423	20975	21527
3	18664	19286	19908	20530	21152	21774	22396	23018	23640	24262
4	20952	21650	22348	23046	23744	24442	25140	25838	26536	27234
5	23442	24223	25004	25785	26566	27347	28128	28909	29690	30471
6	26130	27001	27872	28743	29614	30485	31356	32227	33098	33969
7	29037	30005	30973	31941	32909	33877	34845	35813	36781	37749
8	32158	33230	34302	35374	36446	37518	38590	39662	40734	41806
9	35519	36703	37887	39071	40255	41439	42623	43807	44991	46175
10	39115	40419	41723	43027	44331	45635	46939	48243	49547	50851
11	42976	44409	45842	47275	48708	50141	51574	53007	54440	55873
12	51508	53225	54942	56659	58376	60093	61810	63527	65244	66961
13	61251	63293	65335	67377	69419	71461	73503	75545	77587	79629
14	72381	74794	77207	79620	82033	84446	86859	89272	91685	94098
15	85140	87978	90816	93654	96492	99330	102168	105006	107844	110068

Figure 3: Salary Table 2003-GS (Annual Rates by Grade and Step)

	<2	2	3	4	6	8	10	12
E-9								
E-8							57,163.86	58,135.28
E-7				48,292.03	49,403.71	51,313.22	52,375.93	53,428.93
E-6	39,020.92	41,360.88	42,485.50	43,574.85	44,703.89	47,211.51	48,179.14	49,249.36
E-5	35,353.61	36,680.17	37,757.34	38.897.73	40,665.89	43,291.10	43,892.08	43,892.08
E-4	32,359.98	33,322.22	34,370.09	35,381.21	36,305.00	36,305.00	36,305.00	36,305.00
E-3	30,127.10	31,166.07	32,228.74	32,228.74	32,228.74	32,228.74	32,228.74	32,228.74
E-2	29,041.21	29,041.21	29,041.21	29,041.21	29,041.21	29,041.21	29,041.21	29,041.21
E-1 >4 months of service	26,896.16	26,896.16	26,896.16	26,896.16	26,896.16	26,896.16	26,896.16	26,896.16

Figure 4: Military pay is based upon grade (rank) and years of service[47]

[47] http://usmilitary.about.com/library/milinfo/pay/blenlistedsalary.htm Fiscal Year 2003 Military Pay and Allowances. FY2003 Average Annual Salary Charts. Page 1. 5/27/03.

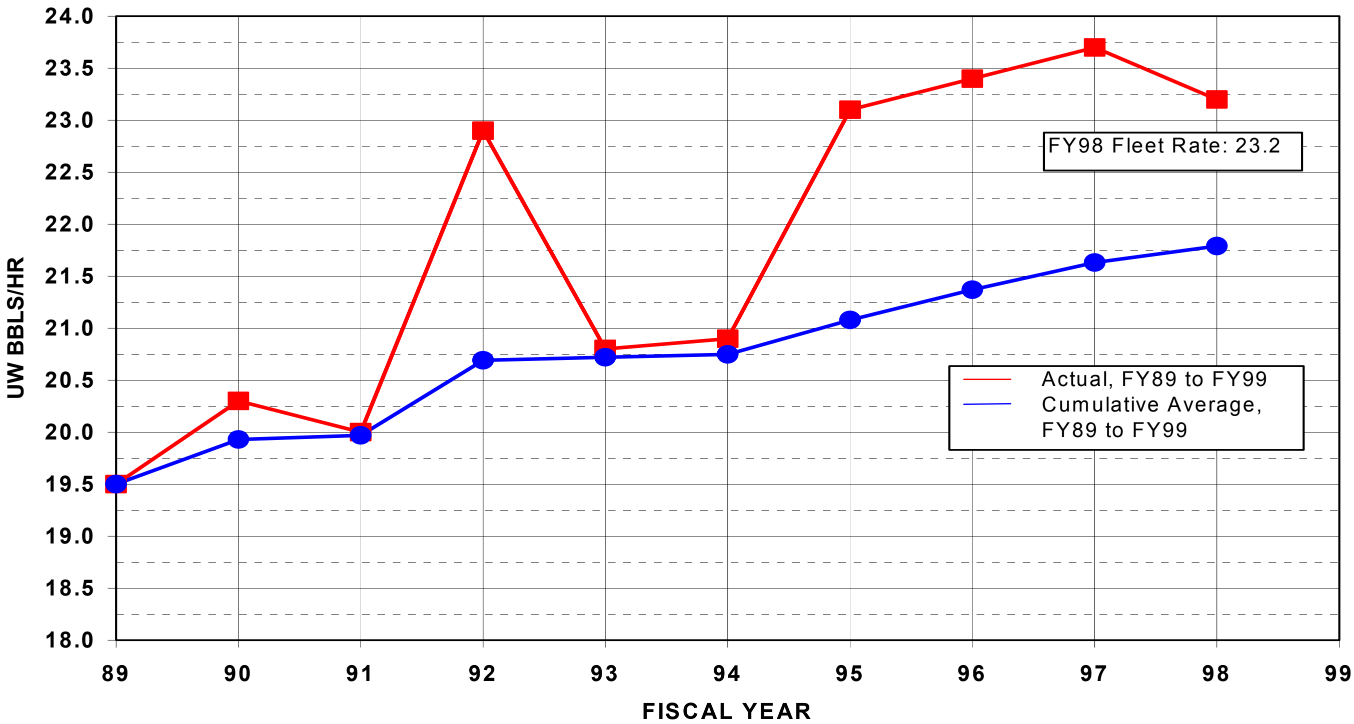

Figure 5: Combined Fleet Underway Fuel Usage Rates (MSC and Reserve Ships excluded)[48]

48 http://www.navsea.navy.mil/ase/Publications/ASE%202000%20Symposium%20Papers/ASE2000%20ENCON%20Paper.doc Pehlivan, H. "Incentivized Energy Conservation (ENCON)". 1999.

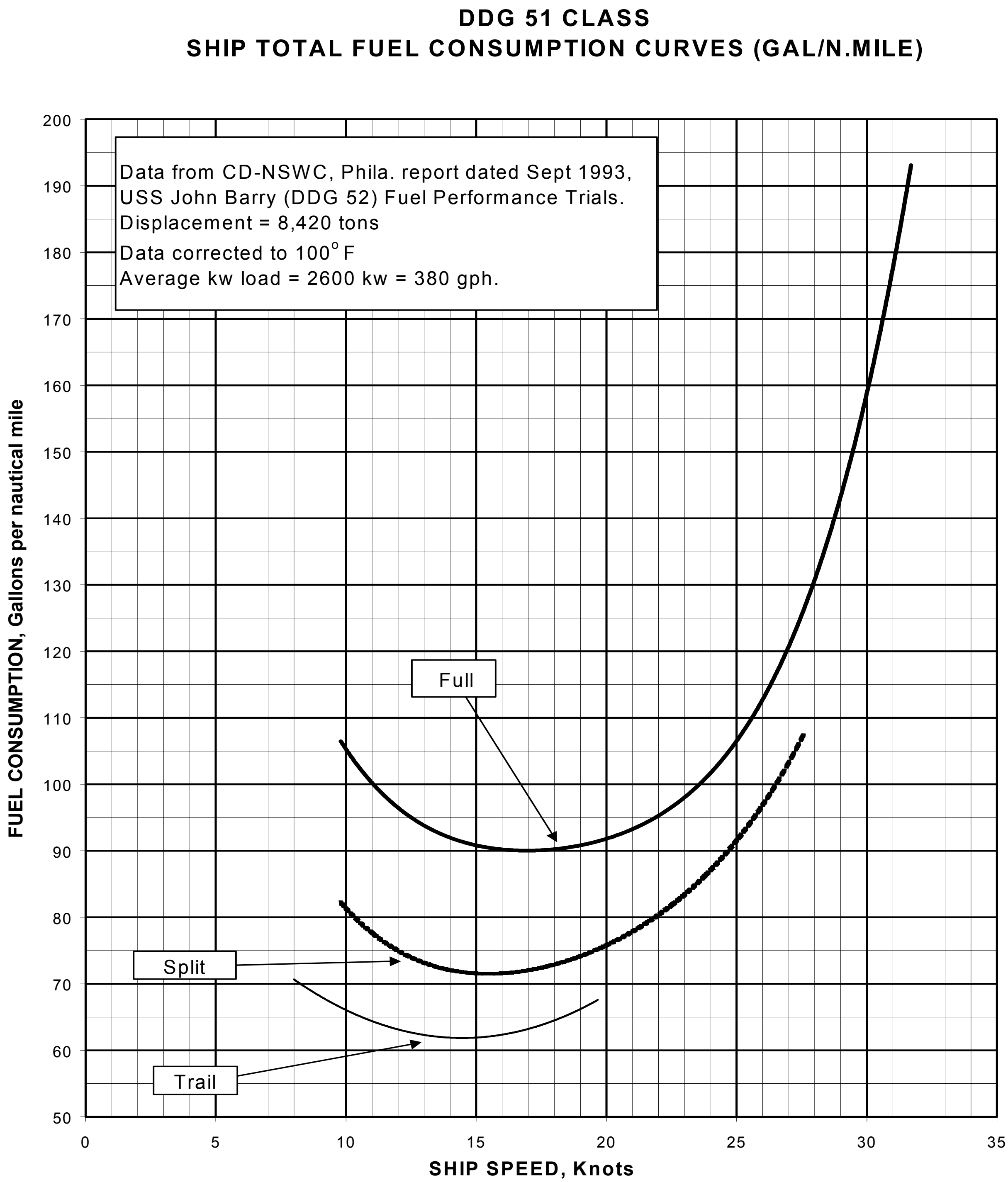

Figure 6: DDG-51 Class Total Fuel Consumption Curves[49]

49 http://www.navsea.navy.mil/ase/Publications/ASE%202000%20Symposium%20Papers/ASE2000%20ENC

Ship class	DFM (barrels)	(gallons)
Carrier (CV)	2,700	113,400
CG-47	725	30,450
DD-963	710	29,820
DDG-51	710	29,820

Table 3: Average Daily Fuel Consumption Rates for Selected Ship Classes[50]

ON%20Paper.doc Pehlivan, H. “Incentivized Energy Conservation (ENCON)”. 1999.

[50] http://www.fas.org/man/gao/nsiad98001/a3.htm Navy Aircraft Carriers. Cost-Effectiveness of Conventionally and Nuclear-Powered Aircraft Carriers. GAO/NSIAD-98-1 -- August 1998. Table III.2

	Barge Maint Cost			Total MT Cost	
Year	**BPM cost**	**BCM cost**			**DISC ANNUAL Cost**
0		-900000	$0.00	-900000	$31,336,324.44
1	-215610		5238345	5022735	
2	-215610		5238345	5022735	
3	-215610		5238345	5022735	
4	-215610		5238345	5022735	
5		-900000	5238345	4338345	
6	-215610		5238345	5022735	
7	-215610		5238345	5022735	
8	-215610		5238345	5022735	
9	-215610		5238345	5022735	
10					
				43620225	

BPM = Barge Preventive Maintenance

BCM = Barge Corrective Maintenance

Table 4: NPV Barge Costs and Benefits (7% Discount Rate)

	BENEFITS		COSTS			
Year	**Barge**	**Pipeline**	**Barge**	**Pipeline**		
0	0	0	-900000	-1,800,000	-2700000	$179,752,226.91
1	5238345	27495178	-5022735	-158006	27552782	
2	5238345	27495178	-5022735	-158006	27552782	
3	5238345	27495178	-5022735	-158006	27552782	
4	5238345	27495178	-5022735	-158006	27552782	
5	5238345	27495178	-900000	-158006	31675517	
6	5238345	27495178	-5022735	-158006	27552782	
7	5238345	27495178	-5022735	-158006	27552782	
8	5238345	27495178	-5022735	-158006	27552782	
9	5238345	27495178	-5022735	-158006	27552782	
10	5238345	27,495,178				
	5238345	274,951,78	-			
	0	0	41,981,880	-3,222,054	249,397,773	

Table 5: NPV of Costs and Benefits of Combined Pipeline and Barge Refueling at a Discount Rate of 7%.

	Pipeline Costs		Total MT Cost			
Year	**PPM cost**	**PCM cost**		**Benefits**		
0		-1,800,000	-1,800,000	0	-1,800,000	$176,308, 024.61
1	-158006		-158006	27495178	27337172	
2	-158006		-158006	27495178	27337172	
3	-158006		-158006	27495178	27337172	
4	-158006		-158006	27495178	27337172	
5	-158006		-158006	27495178	27,337,172	
6	-158006		-158006	27495178	27337172	
7	-158006		-158006	27495178	27337172	
8	-158006		-158006	27495178	27337172	
9	-158006		-158006	27495178	27337172	
10						
			-3222054		244,234,548	

PPM = Pipeline Preventive Maintenance

PCM = Pipeline Corrective Maintenance

Table 6: NPV Total Pipeline Costs and Benefits (7% Discount Rate)

ATERNATIVES	NPV (2% discount rate) in $	NPV (7% discount rate) in $	NPV (10% discount rate) in $
Pipeline	221,332,468.75	176,308,024.61	155,635,424.62
Barge	39,476,878.87	31,336,324.44	27,601,098.14
Combination of Pipeline/Barge	225,926,416.71	179,752,226.91	158,537,021.81

Table 7: NPV Table of Alternatives at Various Discount Rates

ATERNATIVES	Benefits at 7%	Benefits doubled at 7%
Pipeline	176,308,024.61	355,445,395.00
Barge	31,336,324.44	65,465,358.71
Combination of Pipeline/Barge	179,752,226.91	393,018,731.57

Table 8: NPV Table of Alternatives (Benefits Doubled)

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Boardman, A.E. et. al, Cost-Benefit Analysis: Concepts and Practice, 2nd Edition. New Jersey: Prentice Hall, 2000.

Defense Energy Support Center. (2002). Domestic Ships Bunker Contract Bulletin, SPO0600-02-0114; Fort Belvoir, Va., 7 August 2002.

Department of Defense. (1994) DoD 4140.25M, DoD Management of Bulk Petroleum Products, Natural Gas and Coal, Acquisitions and Technology. Washington, DC: 22 June 1994.

Fleet Industrial Supply Center, Pearl Harbor. Pearl City Fuel Annex Site (2002). Retrieved November 5, 2002. http://www.efdpac.navfac.navy.mil/divisions/environmental/pcfuel.htm

Navy Petroleum Office. (1996). NAVPETOFF Instruction 4020.1C, Fort Belvoir, Va. 15 March 1996.

Navy Petroleum Office. (2002). NAVPETOFFNOTE 4265 (FY03 Standard Price Data for 9X and 1B COG items), Fort Belvoir, Va.

Navy Supply Systems Command. (1998). Publication 558, Fuel Management Ashore, Fort Belvoir, Va: U.S. Government Printing Office

Schmokel, N.A. NAVPETOFF Memorandum Feb/DBT/sdw. Subject: Project PRL 98-23 Repair H5 Wharf dtd 7 April 1998.

State of Hawaii Department of Transportation Harbor Division Planning Committee (2002). 2020 Master Plan. Retrieved November 5th from http://www.state.hi.us/dot/harbors/oahu/2020-2.htm

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Fort Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Professor Raymond Franck
   Naval Postgraduate School
   Monterey, California

4. Professor Donald Eaton
   Naval Postgraduate School
   Monterey, California

5. LCDR John Santo Salvo
   Fleet Industrial Supply Center
   Pearl Harbor, Hawaii

6. Master Sergeant Dean Abbott
   United States Pacific Command J4223
   Camp Smith, Hawaii